Measuring UK Woodland Ecosystem Assets and Ecosystem Services

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Abstract

This paper presents the initial experimental UK woodland ecosystem asset and services accounts. These accounts are developed in accordance with the System of Environmental Economic Accounting (SEEA) Experimental Ecosystem Accounting guidelines, while showing some flexibility in its implementation due to UK specific context and needs. This paper discusses the methodology used to develop these accounts, discusses challenges and provides suggestions on improving these accounts over time.

Background

In November 2011, in response to the Natural Environment White Paper (NEWP) commitments, the Office for National Statistics (ONS) published a paper "Towards a sustainable environment – UK Natural Capital and Ecosystem Accounting" to outline its approach to deliver the 'early changes by 2013' to the UK Environmental Accounts. The paper suggested that a pilot study to produce a woodland asset account should be prioritised in the first instance. In December 2012, ONS published a roadmap "Accounting for the value of nature in the UK" to incorporate natural capital into the UK Environmental Accounts. As part of the roadmap, ONS set out a timetable to develop a woodland ecosystem account. **This paper is a first attempt to develop initial experimental statistics on UK woodland ecosystem assets and ecosystem services**. This work is undertaken as part of the Measuring National Well-being Programme, working with the Forestry Commission and the Department for Environment, Food & Rural Affairs.

It is envisaged that the compilation of woodland ecosystem assets and ecosystem services accounts will provide information on the capacity of UK woodland to provide ecosystem services, how these services change over time, monitor ecosystem degradation and flag up evidence and data gaps on important services and characteristics.

ONS has published the following experimental statistics alongside this paper as a first attempt towards providing comprehensive non-monetary and monetary asset accounts on UK woodland:

1. Measuring UK woodland area and timber resources
2. Land Use in the UK
3. Monetary valuation of UK timber resources

As discussed in the paper "Towards a sustainable environment – UK Natural Capital and Ecosystem Accounting", the conceptual model adopted by the UK and the international statistical community for environmental accounts is the United Nations' System of Economic and Environmental Accounts (SEEA), a satellite system of the System of National Accounts (SNA). The accounts produced under

this standard bring environmental and economic information together within a common framework.

A multi-year process of revision to SEEA was initiated by the United Nations Statistical Commission (UNSC). The revised SEEA consists of three parts:

- The Central Framework of agreed concepts, definitions, classifications, accounting rules and tables which, following a period of global consultation, was adopted as the international statistical standard for environmental-economic accounts by the UNSC in February 2012
- Experimental Ecosystem Accounting, which following a global consultation has been endorsed by the UNSC as international guidance in February 2013
- Extensions and Applications, which outlines applications of environmental economic accounting.

ONS aim is to develop woodland ecosystem asset and ecosystem services accounts in accordance with SEEA Experimental Ecosystem Accounting. However, ONS has taken a flexible approach in implementing SEEA Experimental Ecosystem Accounting because it is not a statistical standard but provides guidance on developing ecosystem accounts. This paper is also one of the first attempts in the world to implement SEEA Experimental Ecosystem Accounting guidance in practice. Therefore, this paper also discusses the issues that arose while implementing SEEA Experimental Ecosystem Accounting guidelines in developing UK woodland ecosystem asset and ecosystem services accounts.

This paper starts with a brief introduction to ecosystem assets and ecosystem services. It then discusses the measurement and the accounting structures of ecosystem assets and services and presents the initial experimental UK woodland ecosystem asset and services accounts. The final two sections discuss the challenges and future work on addressing these challenges.

Ecosystem Accounting

The Millennium Ecosystem Assessment[1] defines an ecosystem as 'A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit'. Ecosystem accounting is a concept that provides a coherent and integrated approach to the assessment of the environment through the measurement of ecosystems, and measurement of the flows of services from ecosystems into economic and other human activity. This allows us to gain an insight into the fundamental relationships between these various aspects and to better understand the impact of human intervention upon them.

[1] The Millennium Ecosystem Assessment (MEA) was requested by the United Nations Secretary-General Kofi Annan in 2000. Initiated in 2001, the objective of the MEA was to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being.

Ecosystem assets and ecosystem services

Ecosystem assets

Ecosystem assets are environmental assets that represent the stock of ecosystems within an accounting framework. The SEEA Experimental Ecosystem Accounting defines ecosystem assets as "*spatial areas containing a combination of biotic and abiotic components and other characteristics that function together*." They are the basis upon which the ecosystem functions to provide the ecosystem service flows.

Ecosystem services

Ecosystem services are central in the ecosystem accounting framework since they provide the link between ecosystem assets on the one hand and the benefits received by society on the other. People benefit from both the materials that ecosystems provide (such as the harvesting of timber from woodland) and from the outcomes of natural processes (such as the benefits from clean air that has been filtered by an ecosystem).

Ecosystem services that contribute to human well-being are classified into:

> **Provisioning services** – products such as: food (crops, meat and dairy products, fish and honey); water; fibre (timber and wool); and fuel
> **Regulating services** – benefits such as: water purification; climate regulation; noise and air pollution reduction and flood hazard reduction
> **Cultural services** - non-material benefits, for example: through cultural heritage; recreation or aesthetic experience.

a) Measurement of ecosystem assets

Ecosystem assets can be measured from two perspectives[2]. First, ecosystem assets can be considered in terms of *ecosystem condition* and *ecosystem extent*. Secondly, they can be considered in terms of *expected ecosystem service flows*.

Ecosystem condition and ecosystem extent

The condition and extent of an ecosystem asset determines the capacity of that ecosystem asset to produce ecosystem services. SEEA Experimental Ecosystem Accounting framework states that "*the condition indicates the overall quality of the ecosystem asset in term of its characteristics*". The assessment of ecosystem **condition** involves the selection of appropriate characteristics and associated indicators concerning these characteristics. The **extent** of the asset is the size of the asset and refers to the area of the land covered by an environmental asset (such as woodland).

[2] SEEA Experimental Ecosystem Accounting, page 41

Expected ecosystem service flows

The second perspective is to measure ecosystem assets in terms of expected ecosystem service flows. According to SEEA Experimental Ecosystem Accounting, *a particular combination, or "basket"*, "*of ecosystem services will be generated at a particular point in time from a specific ecosystem asset. The aggregation of all future ecosystem services for a given basket provides, at a point in time, the estimated stock of expected ecosystem services flows*[3].

However, this approach is more challenging to measure in non-monetary terms as it involves the aggregation of expected ecosystem service flows. This is only possible for some services in monetary terms as discounting allows the aggregation of the current value and the future value by converting the future value into today's money.

SEEA Experimental Ecosystem Accounting suggests that there is a relationship between the two perspectives. For example, an improvement in one condition indicator might increase an expected service flow, but on the other hand reduce other expected service flows (if not another condition indicator itself). A complete picture of ecosystem assets could be provided by integrating these two perspectives. However, for ecosystem accounting, it is not necessary to build complete ecosystem models and measure every possible stock and flow. The asset account should be aimed at identifying the most relevant aspect of the ecosystem asset and providing relevant information for analytical and policy purposes.

In light of the above, the physical woodland ecosystem asset account presented in this paper is based on the first perspective – examining the condition and extent of the ecosystem asset.

b) Measurement of ecosystem services

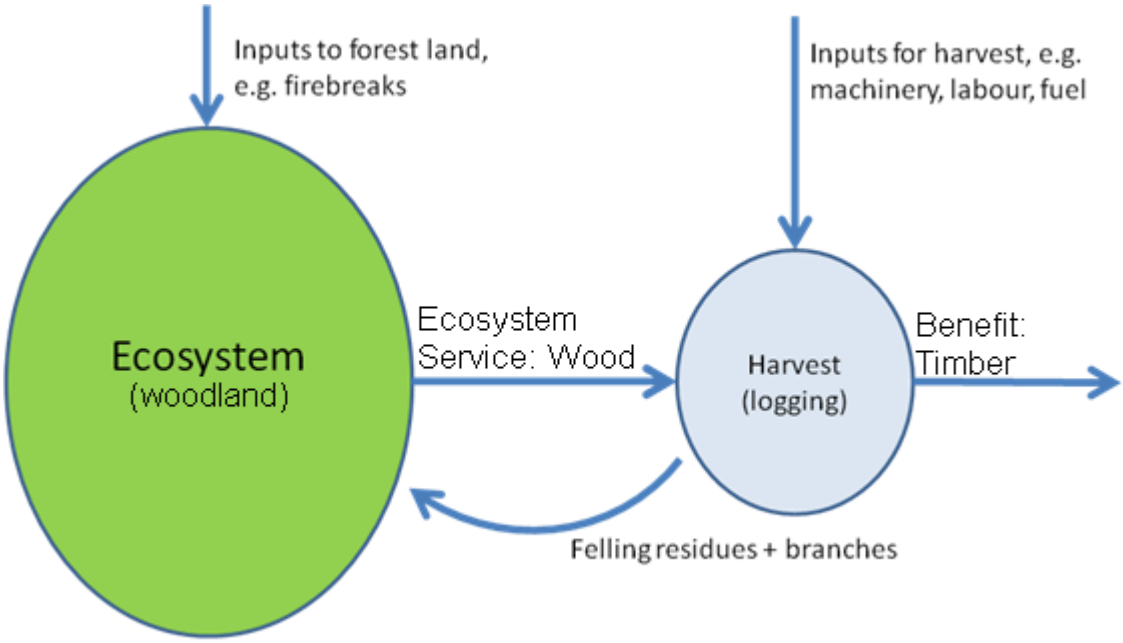
One of the fundamental tenets of ecosystem services is that they are anthropocentric, in that they provide a benefit which is valued by humans. The classification of ecosystem services described in SEEA Experimental Ecosystem Accounting – the Common International Classification of Ecosystem Services (CICES) – fits into the broader picture of ecosystem accounting by providing a structure to classify ecosystem services. This paper has used the latest version of CICES (version 4.3) to classify the relevant woodland ecosystem services. A condensed version of CICES is attached in Appendix A[4].

As mentioned above, ecosystem services are the flow of benefits to society arising from an ecosystem, such as woodland. In particular, these flows are linked to the underlying ecosystem asset, from which the ecosystem services are produced. These linkages are shown diagrammatically, in the context of woodland, in Figure 1 below:

3 SEEA Experimental Ecosystem Accounting, page 41

4 A full version can be downloaded from www.cices.eu/

Figure 1: Woodland ecosystem flows



Source: SEEA Experimental Ecosystem Accounting

Figure 1 shows the linkages between the ecosystem (the woodland), the ecosystem service (wood) and the benefits (harvested timber). The inputs reflect the notion that this account is anthropocentric in the way that the woodland must be managed and the ecosystem service requires human intervention to turn it into a benefit. In the above example, the link between the ecosystem asset and the ecosystem services is the growing stock.

Figure 1 clearly delineates between the ecosystem service and the benefit associated with that service. This is only relevant to provisioning ecosystem services, such as timber, as the focus is on the benefits rather than the ecosystem service itself. This is because provisioning services require human inputs before they can be utilised by people. Hence, the point of measure is the benefit from the ecosystem service, instead of the ecosystem service itself.

On the other hand, for regulating and cultural ecosystem services, the ecosystem service is the point of measure, not the benefits. This is because the ecosystem service itself is distinctly measurable and does not require direct human inputs to produce benefits to humans. For example, the global climate regulation ecosystem service is measured by the ecosystem service of carbon sequestration itself, not the benefit of cleaner air or improved health outcomes.

To summarise, for provisioning ecosystem services the point of measure are the benefits to people arising from the service; whereas, for regulating and cultural services, the point of measure is the ecosystem services themselves.

Ecosystem assets accounting structure

As discussed above, the non-monetary woodland ecosystem asset account presented in this paper is based on the condition and extent of the ecosystem asset. Table 1 provides a broad structure for organising information on ecosystem extent and condition for a given ecosystem asset.

Table 1: Measures of ecosystem, condition and extent at the end of an accounting period

	Ecosystem extent	**Characteristics of ecosystem condition**				
		Vegetation	Biodiversity	Soil	Water	Carbon
	Area	e.g. Leaf area index; biomass; mean annual increment	e.g. species richness; relative abundance	e.g. soil organic matter content; soil carbon; groundwater	e.g. river flow; water quality; fish species	e.g. net carbon balance; primary productivity
Type of land cover						
Forests						
Agriculture land						
Urban areas						
…						

Source: SEEA Experimental Ecosystem Accounting

The land area (extent) changes little over the short term and it is the condition of the asset that mostly influences the ecosystem. It is therefore important that the indicators selected are responsive to changes in the ecosystem as a whole. For each characteristic there could be a number of relevant indicators and ideally each ecosystem service should have at least one indicator in the account to reflect the different aspects of 'condition'. SEEA Experimental Ecosystem Accounting suggests that the selection of characteristics and associated indicators for the measurement of ecosystem condition should reflect scientifically valid measures.

Table 1 shows indicators of ecosystem condition at a point in time, but it does not show changes in ecosystem condition over an accounting period. Following the broad structure of the asset account presented in SEEA Central Framework, Table 2 shows a possible account for ecosystem condition.

ONS has developed an experimental ecosystem asset account for UK woodland based on the accounting structure given in Table 2. The table shows a condition account for an ecosystem with a number of suggested key characteristics; however, the characteristics and the indicators can vary across different types of ecosystem assets depending on the services they provide.

Table 2: Changes in ecosystem condition for an Ecosystem Accounting Unit

	Characteristics of ecosystem condition				
	Vegetation	Biodiversity	Soil	Water	Carbon
Indicators	e.g. Leaf area index; biomass; mean annual increment	e.g. species richness; relative abundance	e.g. soil organic matter content; soil carbon; groundwater	e.g. river flow; water quality; fish species	e.g. net carbon balance; primary productivity
Opening Condition					
Improvements in Condition					
Improvements due to natural regeneration					
Improvements due to human activity					
Reduction in Condition					
Reductions due to extraction and harvest of resources					
Reductions due to ongoing human activity					
Catastrophic losses due to human activity					
Catastrophic losses due to natural events					
Net change					
Closing condition					

Source: SEEA Experimental Ecosystem Accounting

As the extent of an asset is the area of the land, the extent of UK woodland ecosystem is the woodland area. ONS has published experimental statistics on woodland area[5] alongside this paper and therefore the extent account is not presented here. Unlike the ecosystem extent, the measurement of woodland ecosystem condition is not straightforward. The most challenging part is to identify the relevant characteristics and indicators.

Table 2 provides five key characteristics suggested by the SEEA Experimental Ecosystem Accounting with some examples of common indicators; however, it is not an exhaustive list. We have excluded three characteristics from Table 2 and added two additional characteristics (discussed below) to develop the initial experimental woodland ecosystem asset account.

The following characteristics are excluded:

- *Water* – is not a main characteristic within woodland. This is because the woodland area in the UK does not include water surface if the water area is more than 0.5 hectares and normally the water surface area within UK woodland is relatively small. Furthermore, underground water in the woodland is not manageable, so it does not fit the purpose even if a measurable indicator exists

[5] For more details see paper *Measuring the UK Woodland Area and Timber Resources*

- *Soil* - is excluded because further research is required to establish the link of soil quality to the woodland ecosystem

- *Carbon* – carbon sequestration is a key ecosystem service in the woodland and the best indicator of carbon is the service itself. Hence, carbon is recorded in the ecosystem service account and not in the asset account.

We have selected four key characteristics - biomass, biodiversity, access and conservation - of the woodland ecosystem that affects the condition of UK woodland. Table 3 shows a number of indicators to measure these key characteristics. These indicators are experimental and further research is required to establish whether they are fit for purpose or if there are alternative indicators that should be considered. Since there is not a single indicator for assessing a characteristic, multiple indicators have been selected for each characteristic, excluding biodiversity.

Characteristics and indicators

The characteristics and indicators selected to measure the woodland ecosystem assets given in Table 3 are discussed below:

Biomass

Timber is the main source of biomass and provides the most significant provisioning service – extraction of timber - from woodland. The growing stock of standing timber is chosen as the indicator of biomass because it provides information on the amount of timber resources that are available for wood products. The growing stock refers to the current volume of the standing timber in woodland, expressed in cubic metres. The details of the stock of timber are recorded in the timber resources asset account[6].

The health of trees is also important to reflect the condition of the timber resources. This indicator is selected in Table 3 but further analysis is required on how existing data[7] could be manipulated and incorporated as an indicator.

Biodiversity

Biodiversity is an important characteristic that influences ecosystems. Currently bird population is the only indicator available to represent biodiversity in UK woodland. There are long term data available to monitor changes in woodland bird population in the UK woodland bird index. Birds are responsive to changes in the environment and the condition to the ecosystem asset because they are at the top of the food chain, and therefore, the health of the population reflects changes in underlying biodiversity.

[6] For more details see the paper "Measuring the UK Woodland Area and Timber Resources" that ONS is publishing today alongside this paper

[7] Forestry Commission has some data regarding the tree health but further analysis is required

Access

Some of the main ecosystem services provided by woodland are cultural services. Woodland is commonly used for recreational activities and access to woodland directly influences cultural service flows. If woodland is close to residential areas, people may visit them more frequently. The Woodland Trust provides regular data on accessible woodland[8]. The woodland access standard is measured in terms of the population with access to woodland of at least 2 hectares within 500 metres of their home, and the population with access to woodland of 20 hectares or more within 4 kilometres of their home. These indicators are chosen because they take into account the distance between the woodland and the residential area, which might affect someone's decision to visit woodland and thus increase or reduce the cultural aspect of the woodland.

Another factor that could affect visits to woodland is the availability of facilities. Though, further analysis is required to understand how this factor can be measured.

Conservation

The protected area is chosen as the indicator of conservation because they are designed for the conservation of nature in the woodland to ensure the next generation can enjoy the benefits provided by the woodland. The area protected indicates the willingness to preserve plants, animals or the ecosystem itself for the next generation.

Initial account for UK woodland ecosystem assets

Based on the above discussion, Table 3 presents an initial experimental UK woodland ecosystem asset account. The table shows opening and closing stock between two accounting periods - 2007 and 2012. Due to limited data, it is challenging to measure any fluctuation in the condition due to improvements and reductions between these two accounting periods and therefore any changes in condition are recorded as net change.

Not all the data in Table 3 refer to 2007 and 2012 due to different frequencies of various data sources. The frequency of the data varies from annual to 5 years. Therefore, the latest available data are considered as a proxy whenever the data for 2007 and 2012 were not available. It is reasonable to make such assumptions because the condition of ecosystem assets does not change significantly over a short time period.

[8] Accessible woodland is defined as any site that is permissively accessible to the general public for recreational purposes. This includes sites with unrestricted open access and restricted but permissive access.

Table 3: UK woodland ecosystem asset account

2007-2012	Characteristics of ecosystem condition						
	Biomass		Biodiversity	Access			Conservation
Data Sources		Forest Resource Assessment 2010	DEFRA, BTO, RSPB[9]	Woodland Trust			Forestry Statistics[10]
Data Quality[11]							
				Accessible woods			
Indicator	Tree health[12]	Growing stock	Woodland birds (Specialist) 1970=100	Population with access to 2 ha[14]+ within 500 meters	Population with access to 20 ha+ within 4 kilometers	Facilities[13]	Protected area
Measurement unit		million m³ overbark	index	%			thousand ha
Opening Condition 2007	-	340 (2005)[15]	66 (2007)	11 (2004)	56 (2004)	-	206 (2007)
Improvements in Condition							
Improvements due to natural regeneration							
Improvements due to human activity							
Reduction in Condition							
Reductions due to extraction and harvest of resources							
Reductions due to ongoing human activity							
Catastrophic losses due to human activity							
Catastrophic losses due to natural events							
Net change	-	39	6	5	9	-	0
Closing condition 2012	-	379 (2010)	72 (2011)	16 (2009)	65 (2009)	-	206 (2012)

[9] BTO: British Trust for Ornithology; RSPB: Royal Society for the Protection of Birds
[10] Source: Protected Forest Areas in the UK (S Pryor & G Peterken, 2001)
[11] Data quality is categorised into: Low – Red; Medium – Yellow; High – Green, based on the following criteria: Regularity of data , Coverage (National level, sample size) and Reliability (methodology consistency)
[12] Further analysis is required how existing data could be manipulated and incorporated as an indicator
[13] Further analysis is required how this indicator should be measured
[14] Ha = Hectares
[15] The brackets show the year of the data

Ecosystem services accounting structure

SEEA Experimental Ecosystem Accounting provides a general framework for ecosystem services account. This framework sets out a guideline of what the ecosystem services (or flow) account should look like when compiled alongside all the main habitat types (eg. woodland, urban, agriculture etc). The idea is that all the major habitat types will have their ecosystem services presented alongside each other as shown in Table 4 below:

Table 4: Physical flows of ecosystem services for an Ecosystem Accounting Unit

2012	Type of Land Cover Economic Unit				
	Agricultural	**Urban**	**Woodland**	**Wetlands**	**…**
Type of ecosystem service (by CICES)					
Provisioning services					
Regulating services					
Cultural services					

However, in practice this needs to be further disaggregated because summing the individual non-monetary flows of ecosystem services is not possible as they are measured in different units. Once the woodland ecosystem services account is compiled (discussed in the next section), it will broadly fit into Table 4.

As discussed earlier UK woodland ecosystem services account is compiled using the Common International Classification of Ecosystem Services (CICES). However, the CICES contains almost fifty distinct ecosystem service classes in total. We have selected a few services in this paper. Some of these services will be explored in the future with a possibility of including more services in the woodland ecosystem services account. SEEA Experimental Ecosystem Accounting has provided a set of criteria to select the relevant ecosystem services for a habitat. The criteria are given in Table 5 below:

Table 5: Criteria for prioritisation of ecosystem services for accounting purposes

	Criterion	Brief explanation
Environmental Concerns		
1	Sensitivity of the service to changes in the environment, including from anthropogenic stressors	Consideration may be given to services that are sensitive to environmental change or will reflect changes in natural capital stocks
2	Likelihood of irreversible loss of ecosystem services including by the supplying ecosystem being pushed past a significant threshold and out of its "safe operating range"	Consideration may be given to services that are generated from ecosystems that are generally understood to be close to significant environmental thresholds
Policy context		
3	Possibility to influence environmental and/or economic policy and decision making (decision making context)	Consideration may be given to services that can relatively easily be influenced by decision making in order to have maximum relevance for policy making.
4	Economic importance of the ecosystem service	Consideration may be given to those services that generate the highest economic benefits
Data and methods		
5	Availability of broadly accepted methods for analysing ecosystem services supply in physical terms at a high aggregation level	Consideration may be given to services for which broadly accepted modelling / quantification techniques are available
6	Availability of broadly accepted methods for analyzing ecosystem services supply at a high aggregation level in monetary terms	Consideration may be given to services for which broadly accepted valuation approaches are available
7	Availability of data for measuring ecosystem services in physical terms	Producing national level accounts will often require scaling up estimates of ecosystem services to a national level based on underlying spatial data. Both point-based data and spatially explicit data (e.g. land cover, soils, water tables, ecosystem productivity, etc.) are required to analyse a service at the national level
8	Availability of data for measuring ecosystem services in monetary terms	
9	Plans to generate new data on ecosystem services supply	A firm intent or high likelihood that new environmental monitoring will provide essential data

Source: SEEA Experimental Ecosystem Accounting

The focus of the initial experimental account presented in this paper is to select those services for which data are currently available. Therefore, the main criterion adopted to select the woodland ecosystem services for the experimental account presented in this paper is *data and methods*. Other criteria are equally important too, for example, criterion four (Table 5) is important in developing the monetary ecosystem services account, but this needs to be further explored in future. To stress the importance of other ecosystem services for which data are not currently available, we have shown landscape, flood protection, and bequest and existence in the woodland ecosystem services account. The National Ecosystem Assessment provides information on the important ecosystem services; however, this needs to be further explored in an accounting context.

A partial list of the ecosystem services provided by woodland based on the CICES is given below. These services are selected due to data availability; however, data on some of the services listed below are based on one-off studies; nevertheless, these services are included to provide an overview of the services that UK woodland provide. The following services are included in the initial experimental woodland ecosystem services account given in Table 6.

Provisioning services

- *Wild plants and their outputs* - This class consists of wild plants used for human consumption as food, such as wild berries and fruits
- *Wild animals and their outputs* - This class is similar to the wild plants and includes wild venison and honey
- *Fibres and other materials from plants and animals for direct use or processing* - This class consists of materials rather than nutrition, though the end product is still some form of human consumption. Generally timber is the major component of this class, though ornamental material can also be included here
- *Genetic materials from all biota* - This class includes items such as medicines and genetic materials
- *Plant-based energy resources* - In a woodland context, this class primarily comprises wood fuel.

Regulating services

- *Global climate regulation*[16] - This category includes carbon sequestration, and the data presented in Table 6 relates to how much carbon is sequestered by woodland
- *Flood protection* - This category is considered important in relation to woodland and therefore is included in Table 6; however, currently, there are no physical data available for the flood protection service from woodland. Further research is required to explore the possibility of measuring flood protection arising from woodland.

Cultural services

- *Experiential use of plants, animals and landscapes* - This category is broadly the *landscape* service that woodland provides. This is likely to be an important service, especially when considering the monetary valuation of ecosystem services. However, further research is required to identify the unit to measure *landscape* in non-monetary terms

[16] In CICES this category is listed as "Global climate regulation by reduction of greenhouse gas concentrations".

- *Physical use of landscapes* - This class shows the total number of visits to woodland in Great Britain (England, Wales and Scotland)

- *Heritage and cultural* - This class includes the percentage of people who visited a woodland and "been to see a historic site" within a woodland

- *Symbolic* - This class is closely related to the above "heritage, cultural" class and is represented in Table 6 by the percentage of people number of people who have visited woodland and "been to see ancient trees" within woodland

- *Bequest and existence* - This class is considered important as there are many measures – such as the Forestry Commission's Forestry Standard – in place which displays a willingness to preserve nature. Currently, this is not directly measurable in non-monetary terms. However, this could be valued in monetary terms by using proxies.

Initial account for the UK woodland ecosystems services

Based on the above services, Table 6 presents an initial experimental UK woodland ecosystem services account. An important ecosystem services accounting objective is to analyse changes over time; therefore, Table 6 presents two accounting periods - 2007 and 2012. Not all the data in Table 6 refer to 2007 and 2012 due to different frequencies of various data sources. The frequency of the data varies from annual to 5 years. Therefore, the latest available data were considered as a proxy whenever the data for 2007 and 2012 were not available. The data sources and the methodology to construct the table are given in Appendix A.

Table 6: Initial UK woodland ecosystem service accounts

Class	Examples	Services 2007	Services 2012	Data source	Data quality
Provisioning services					
Wild plants and their outputs	Wild berries, mushrooms	154 tonnes (2005)	154 tonnes (2010)	FRA	
Wild animals and their outputs	Game, honey	3,700 tonnes (2005)	3,700 tonnes (2010)	FRA	
Fibres and other materials from plants for direct use or processing	Timber, flowers	8,676 thousand tonnes[17] (2007)	9,520 thousand tonnes (2012)	FRA, Forestry Statistics	
Genetic materials from all biota	Medicines	15 tonnes (2005)	15 tonnes (2010)	FRA	
Plant-based energy resources	Wood fuel, straw, energy plants	500 thousand tonnes (2007)	1,300 thousand tonnes (2011)	Forestry Statistics	
Regulating services					
Global climate regulation	Carbon sequestration	14 million tonnes CO2 (2007)	9.7 million tonnes CO2 (2012)	Forestry Statistics	
Flood protection		Not available	Not available	N/A	
Cultural services					
Experiential use of plants, animals and landscapes	Bird watching, landscape	Not available	Not available	N/A	
Physical use of landscape	Walking, climbing, leisure hunting	317 million visits (England 2009) 64m (Wales, 2008) 72m (Scotland, 2007)	358 million visits (England, 2011) 86m (Wales, 2011) 65m (Scotland, 2011)	MENE, ScRS, WORS	
Heritage, cultural		33% of unique visitors (2009)	24% of unique visitors (2011)	POF	
Symbolic	Emblematic plants, national symbols	16% of unique visitors (2009)	6% of unique visitors (2011)	POF	
Bequest and existence (of woodland)	Willingness to preserve plants, ecosystems and landscapes	Not available	Not available	N/A	

Sources: Forest Resource Assessment (2005, 2010); Monitor of Engagement with the Natural Environment (2011-12), Welsh Outdoor Recreation Survey (2011) and the Scottish Recreation Survey (2011); Forestry Statistics (2007, 2012); Public Opinion of Forestry (2009, 2011). Note that the FRA sources above typically refer to one-off studies that have been completed in the past (FRA, 2005, page 53 and FRA, 2010, page 55-56). Hence, their low quality is largely based on irregularity.

Challenges

This paper is a first attempt to develop woodland ecosystem asset and services accounts in the UK. There are a number of challenges and issues that need to be addressed in developing a comprehensive woodland ecosystem account. The main challenges are given below:

[17] green tonnes used for timber removals

- Woodland provides a number of ecosystem services and ideally the most important services should be prioritised while developing an ecosystem account. However, due to a number of challenges, such as identification of important woodland ecosystem services and lack of physical data, this paper has focused on those services for which data are currently available. Even where data are available, the sources are infrequent and some of them are one-off studies. Due to this, a number of important ecosystem services such as landscape and flood protection are currently missing from the woodland ecosystem services account

- It was very challenging to measure the condition of UK woodland ecosystems by selecting the right characteristics and indicators. This paper has suggested a number of characteristics and indicators to assess the condition of UK woodland, but these metrics are experimental. SEEA Experimental Ecosystem Accounting suggests that the selection of characteristics and associated indicators for the measurement of ecosystem conditions should reflect scientifically valid measures. Therefore, more research is required to investigate whether the suggested metrics is fit for purpose

- One of the main objectives to compile the ecosystem account is to determine the relationship between the ecosystem asset and service. However, the process is challenging because the link between these two aspects are quite complex

- Another challenge is to capture the health of woodland and its resilience to pests and diseases. This paper has provided tree health as an indicator to assess the biomass characteristics of woodland ecosystem condition. However, due to a lack of reliable estimates, it is not measured.

Future work

ONS will work with the Forestry Commission, Other Government Departments and experts to explore how best to address the data gaps highlighted in this paper to include important services into the non-monetary woodland ecosystem services account. We will also explore the options of choosing alternative characteristics and indicators to assess the woodland ecosystem condition.

Another major development in future work is to convert the non-monetary ecosystem services account into a monetary account. ONS has published the monetary valuation of timber resources alongside this paper. The next step is to value the woodland ecosystem services, which is the second perspective[18] to measure ecosystem assets in terms of expected ecosystem service flows. This is a non-trivial exercise in terms of data availability and dealing with appropriate methods. It will also be important to scope out and prioritise what services users think are important to be valued.

[18] Refer to page 4 of the paper

Appendices

Appendix A

Data sources for Table 6

Provisioning services

Wild plants and their outputs

The data are taken from the Forestry Commission's submissions to the Forest Resources Assessment[19] (FRA 2005, 2010) and specifically includes the estimated amount of mushrooms, bilberries and elderflowers harvest from UK woodland. The data for 2007 is from the FRA 2005 release and the data for 2012 is from the FRA 2010 release.

2007 services:

50 (mushrooms) + 4 (bilberries) +100 (elderflowers) = 154 tonnes

2012 services:

50 (mushrooms) + 4 (bilberries) +100 (elderflowers) = 154 tonnes

Wild animals and their outputs

The data for wild venison is taken from the FRA 2005 and 2010.

2007 services:

3,500 (venison) + 200 (honey) = 3,700 tonnes

2012 services:

3,500 (venison) +200 (honey) = 3,700 tonnes

Note, that the data for honey in 2007 and 2012 are both from FRA 2010.

Fibres and other materials from plants and animals for direct use or processing

In Table 6 timber removals are included in this class. The data for timber removals in 2007 and 2012 are taken from supporting data to the Forestry Commission's National Statistics release on UK Wood Production and Trade: provisional 2012 data and data for foliage and moss are taken from the FRA 2005 and 2010. The data for timber removals presented here also includes round wood deliveries which are believed to be used for wood fuel. Hence, the wood fuel reported in this account is subtracted from the total removals figure to avoid double counting.

[19] The FRA is a report submitted to the Food and Agriculture Organisation of the United Nations every 5 years.

2007 service:

45 (foliage and moss) + 8,736,000 (softwood) + 440,000 (hard wood) + 14 (dyes and colorants = 9,176,059 tonnes – 500,000 (from wood fuel) = 8,676,059 tonnes

2012 service:

45 (foliage and moss) + 10,084,000 (softwood) + 536,000 (hardwood) + 14 (dyes and colorants) = 10,620,059 tonnes – 1,100,000 (from wood fuel) = 9,520,059

Genetic materials from all biota

Currently, some data are available for yew clippings, which are used as a cancer treatment. The data for this is from the FRA 2005 and FRA 2010 releases.

Plant-based energy resources

Data on round wood deliveries for wood fuel in 2007 and in 2012 are taken from supporting data to Forestry Commission's National Statistics release on UK Wood Production and Trade: provisional 2012 data.

2007 service:

200,000 (softwood) + 300,000 (hardwood) = 500,000 green tonnes

2012 service:

900,000 (softwood) + 400,000 (hardwood) = 1,300,000 green tonnes

Note, that round wood deliveries for wood fuel are subtracted from timber removals to avoid double counting.

Regulating services

Global climate regulation[20]

This data are taken from Forestry Statistics (2007, 2012).

Flood protection

Data not available

[20] In CICES this category is listed as "Global climate regulation by reduction of greenhouse gas concentrations".

Cultural services

Experiential use of plants, animals and landscapes

Data not available

Physical use of landscapes

- The total visits are based on the Monitor of Engagement with the Natural Environment (MENE) survey for England, Welsh Outdoor Recreation Survey (WORS) for Wales and the Scottish Recreation Survey (ScRS) for Scotland. The data for Northern Ireland are not available. These surveys are not directly comparable due to different methodologies and therefore they are not added together

- The MENE numbers are based on the type of place visited from question five of the survey: "which of the following list of places best describes where you spent your time during your visit?" The data for 2012 is taken from MENE 2011-12 surveys, which were conducted between February 2011 and March 2012. The data for 2007 are from the MENE 2009-10 survey

- The WORS visits data are based on a question asked to everyone who had visited the outdoors: "what type of places they have visited?" The data shown for 2007 are from the 2008 survey and the data shown for 2012 are taken from the 2011 survey

- The ScRS visits data are also based on a question asked to respondents who had visited an outdoor place in the past four weeks: "what type of place they had visited?" Unlike the above, the ScRS survey was yearly and hence the data for 2007 and 2012 are taken from the 2007 and 2011 surveys. The ScRS survey has now finished, and will be replaced by Scotland's People and Nature Survey.

Heritage, cultural

The data are taken from Public Opinion of Forestry (POF 2009, 2011). The POF survey shows the percentage of respondents who had visited a woodland and "been to see a historic site" as part of their pursued activities whilst visiting the woodland. It should also be noted these activities undertaken on a visit to woodland are not mutually exclusive.

Symbolic

The data for this class is taken from Public Opinion of Forestry (2009, 2011). The POF survey shows the percentage of respondents who had visited a woodland and "been to see ancient trees" as part of their pursued activities whilst visiting the woodland.

Bequest and existence

Data not available

Appendix B

The Common International Classification of Ecosystem Services (CICES) 4.3

Section	Division	Group	Class
This column lists the three main categories of ecosystem services	*This column divides section categories into main types of output or process.*	*The group level splits division categories by biological, physical or cultural type or process.*	*The class level provides a further sub-division of group categories into biological or material outputs and bio-physical and cultural processes that can be linked back to concrete identifiable service sources.*
Provisioning	Nutrition	Biomass	Cultivated crops
			Reared animals and their outputs
			Wild plants, algae and their outputs
			Wild animals and their outputs
			Plants and algae from in-situ aquaculture
			Animals from in-situ aquaculture
		Water	Surface water for drinking
			Ground water for drinking
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing
			Materials from plants, algae and animals for agricultural use
			Genetic materials from all biota
		Water	Surface water for non-drinking purposes
			Ground water for non-drinking purposes
	Energy	Biomass-based energy sources	Plant-based resources
			Animal-based resources
		Mechanical energy	Animal-based energy
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals
			Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems
			Dilution by atmosphere, freshwater and marine ecosystems
			Mediation of smell/noise/visual impacts
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates
			Buffering and attenuation of mass flows
		Liquid flows	Hydrological cycle and water flow maintenance
			Flood protection
		Gaseous / air flows	Storm protection
			Ventilation and transpiration
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal
			Maintaining nursery populations and habitats
		Pest and disease control	Pest control
			Disease control
		Soil formation and composition	Weathering processes
			Decomposition and fixing processes

		Water conditions	Chemical condition of freshwaters
			Chemical condition of salt waters
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations
			Micro and regional climate regulation
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land/seascapes in different environmental settings
			Physical use of land-/seascapes in different environmental settings
		Intellectual and representative interactions	Scientific
			Educational
			Heritage, cultural
			Entertainment
			Aesthetic
	Spiritual, symbolic and other interactions with biota, ecosystems, and land/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic
			Sacred and/or religious
		Other cultural outputs	Existence
			Bequest

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